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THE POSITIVE ELECTRON

By KARL K. DARROW

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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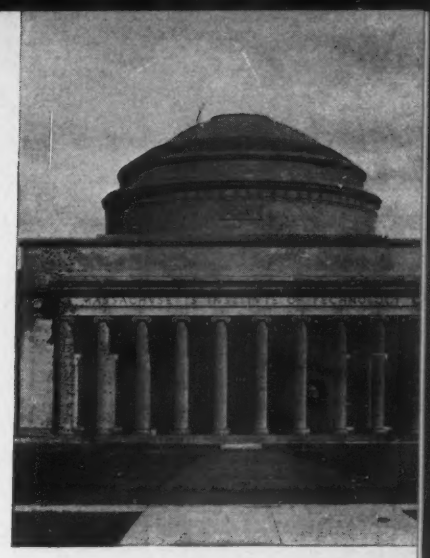

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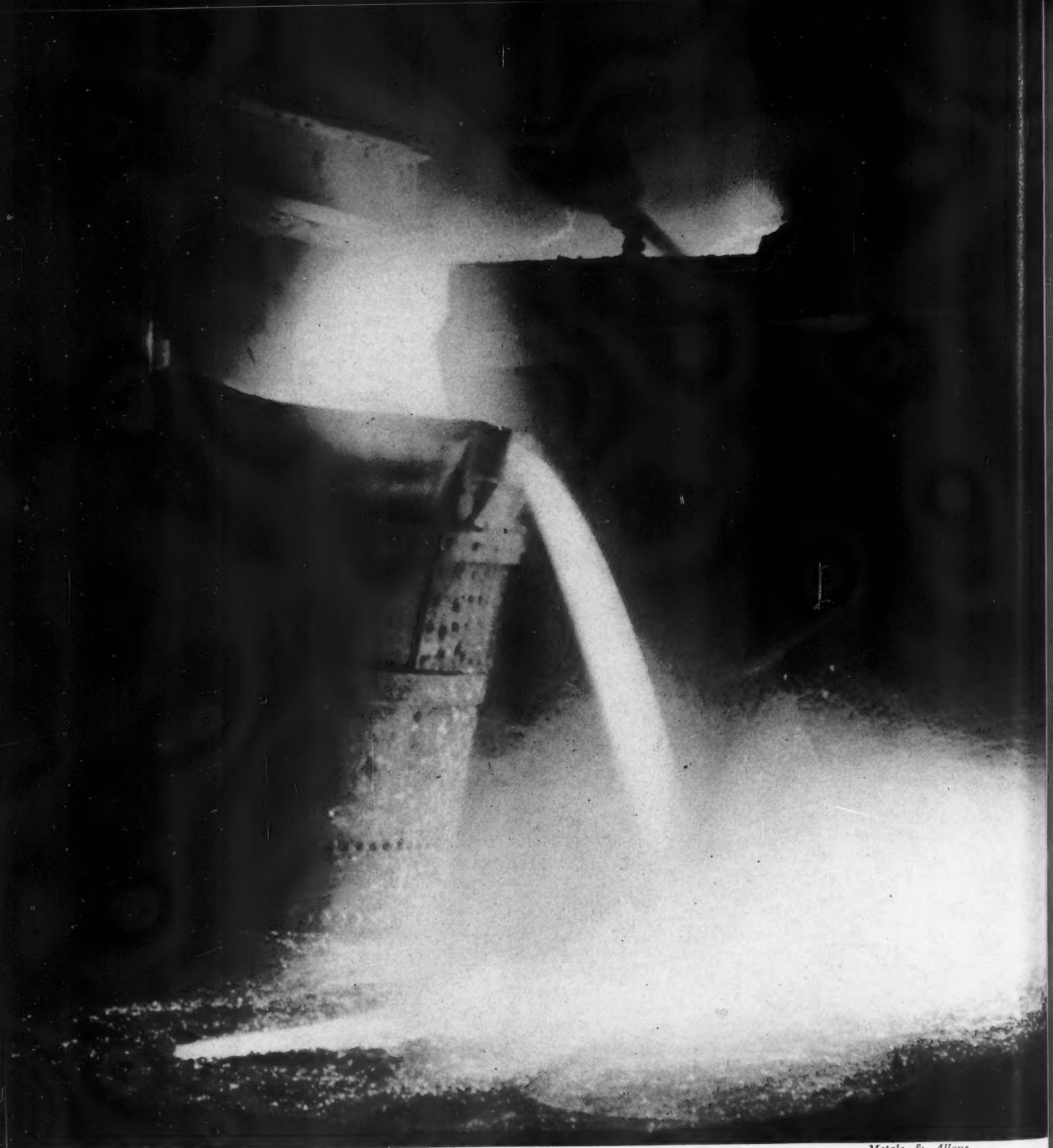


Metals & Alloys

MOLTEN LIGHT

THE POSITIVE ELECTRON

By ***KARL K. DARROW***
Bell Telephone Laboratories

ONLY a couple of years ago, in the course of a big program of cosmic-ray research which Millikan had organized, C. D. Anderson was using the expansion-chamber or cloud-chamber of C. T. R. Wilson to observe the paths of ionizing particles belonging to these rays. Millikan and Anderson were not the first to do this. Others had already photographed the long straight tracks which these particles leave behind them and had furthermore observed that in a moderate magnetic field these tracks are either very slightly curved or not sensibly curved at all, so that the corpuscles which make them must be very fast. Anderson, however, made two important innovations.

Scientific Monthly

Fig. 1—Track of a 3,000,000-volt positive electron springing from aluminum exposed to Alpha-rays (the long track concave to right; the thick track is that of a proton, the others of negative electrons).

Previously, everybody had set up the expansion-chamber with its axis vertical and its breadth horizontal, which is the most convenient way. Be it remembered that this chamber is a broad, short cylinder filled with air or some other gas, its upper end closed by a movable wall, which is the head of a piston. When the piston-head is suddenly pulled back through the proper distance (a matter of careful adjustment) and the gas expands to the proper degree, the moisture in the gas condenses upon whatever ions there are; and in ideal conditions each droplet of water is the investiture of some ionized atom or molecule, and every ion is clothed in a visible particle of mist. Long lines of these visible particles mark out the paths of all the ionizing particles which have traversed the chamber shortly before the expansion. Now in the commoner kinds of experiment with Wilson's chamber, the ionizing particles proceed from some sort of laboratory source, a piece of radium, for instance, which can easily be set in the same horizontal plane as the rest of the apparatus; and then it is convenient to have the axis of the chamber verticle, for the rays traverse the entire width of the gas beneath the cover-plate glass. But the ionizing particles of the cosmic rays mostly move in directions close to the vertical, and evidently the traditional orientation is a very poor one for observing these. Anderson accordingly turned the whole apparatus on its side, so that the breadth of the chamber should lie in a vertical plane; and this is now the universal practice in cosmic-ray research. Such was the first of Anderson's innovations; but the second and greater one consisted in fitting into the chamber a leaden plate, of a thickness of several millimeters.

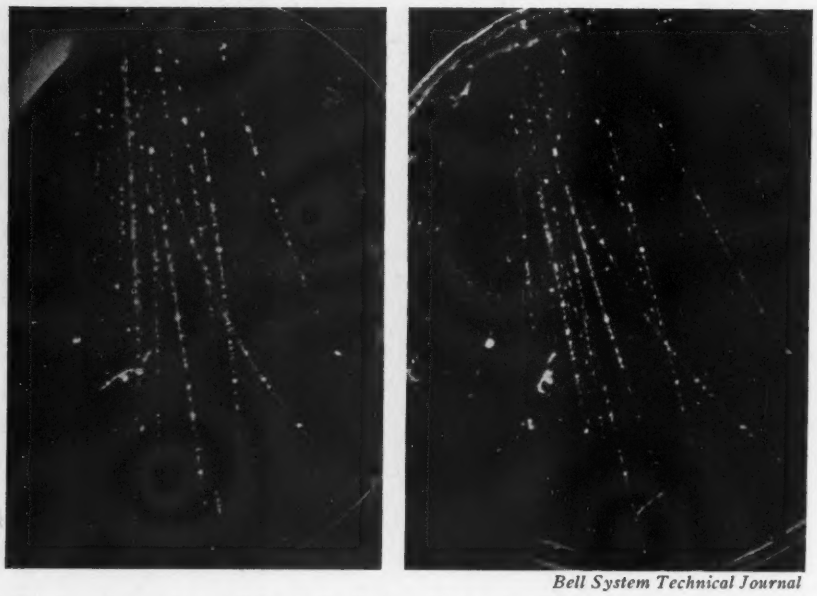
Many of the ionizing particles of the cosmic rays have so great a momentum that they are able to pierce through even such a barrier with no measurable deflection. Often indeed they are moving so tremendously fast that even in a strong magnetic field their tracks seem perfectly straight on both sides of such a plate.[1] Anderson, however, had a magnetic field exceptional both for strength and for extensiveness, and a chamber of corresponding breadth (the field, of course, is parallel to the axis and perpendicular to the cover-plate of the chamber); and now and then he observed a track which traversed the plate and was more strongly curved on one side thereof than on the other.

Consider any such a track. The corpuscle which made it must have been going from the side where the curvature is less and the speed consequently greater, to the side where the curvature is greater and the speed consequently less. Otherwise we should have to assume that the corpuscle had picked up energy—a great deal of energy, tens of millions of electron-volts, indeed—in passing through the lead; and this seems inadmissible. Such a picture therefore fixes the sense in which the corpuscle described the track; and this fixing of the sense is not a trivial matter at all, but of the utmost importance; for with it the observer can tell from the picture (and from his knowledge of the magnetic field) whether the corpuscle was positive or negative, and without it he can not.

On the second of August, 1932, Anderson had a great piece of luck: he operated his expansion-chamber at just the right moment after the passage of a particle, which by this test was proved to be positive. This by itself is no sensational statement; there are various familiar kinds of positive corpuscles of much greater mass than electrons—alpha-particles and protons especially—and one must first of all inquire whether Anderson's particle could have been one of these. All these, however, are ruled out by the length and the appearance of the track. First, as to the appearance, every one who has studied cloud-chamber pictures knows that the tracks of massive particles such as alpha-particles and protons are always much fatter and thicker than those of fast electrons. The massive particles produce many more ions per unit length of path, and therefore many more droplets of condensed water, than do the electrons. The dif-

Editor's Note: Dr. Darrow has based this article on one which he wrote for *The Scientific Monthly* of January, 1934. The author has altered the original article considerably and brought it up to date by the addition of several post-January developments. The extent of these new discoveries is indicative of our rapidly growing knowledge of the positive electron.

[1] A magnetic field bends the path of a charged particle moving, or having a component of motion, perpendicular to its own direction; the faster the particle, the less the curvature. The undeflected particles might conceivably have been uncharged, but from all we know it is extremely unlikely that an uncharged particle would ionize sufficiently many atoms of the gas to make so conspicuous a track.



Bell System Technical Journal

Fig. 2—A cosmic-ray "shower" of some 16 tracks. The two tracks which are concave to the right are due to positive electrons.

ference is very striking to the eye; an illustration may be seen in Fig. 1. Now the famous track which Anderson observed was definitely of the thin and slender type, scantily furnished with droplets; and any one of experience would say on looking at it, "Here is the track of an electron!"

This by itself is not conclusive, for according to theory a proton moving with enormous speed—much greater than any yet attained in the laboratory—would likewise produce a thin and scanty track. Here, however, the curvature of the path bears testimony. So fast a proton would not be so much deflected in this magnetic field; and we can state as a fact of experience that if a proton or an alpha-particle in such a field had left behind it a trail of such a curvature, that trail would have been much fatter and thicker than the one which Anderson observed. Not only would it have been thicker, it would also have been much shorter; for the massive particle would have squandered its energy so rapidly in forming ions that its course would have come to an end in five millimeters, whereas the actual path beyond the plate was five centimeters long.

Anderson's particle was therefore much more like an electron, in everything but the sign of its charge, than it was like a proton or an alpha-particle. Now the question arises: How accurately can we estimate its charge and its mass from the length and the appearance of its track? This, as one can readily imagine, is a very intricate theoretical problem. It will always be an important problem, but luckily it is not so urgent as it used to seem; for Thibaud has succeeded in applying one of the classical deflection methods of measuring charge-to-mass ratio, and it is altogether likely that eventually we shall have as accurate a value of this ratio for positive as we do for negative electrons. We are still far from this standard—Thibaud thus far says only that the two values are within 15 per cent of one another; but even this is already a great advance over the previous estimates, and an important result in itself; the ratio for the next lightest of positive particles, the one hitherto supposed the lightest of all, is only .0054 as great as that of electrons.

The scene now shifts to the Cavendish Laboratory of Cambridge (England), where Blackett and Occhialini were also studying cosmic rays with an expansion-chamber lying on its side. They economized their time and their supply of plates by setting up a pair of Geiger counters, one on each side of the cloud-chamber, and a mechanism so contrived that the chamber would expand when and only when both of the counters should react at the same or nearly the same instant. Such a coincidence might mean that a single ionizing particle had passed through both the counters; if so, its track would appear in the cloud-chamber lying between. Or again it might mean that somewhere in the neighborhood there had been a sort of atomic explosion, with ionizing particles hurled in all directions; in which case, some of these might pass through the cloud-chamber itself. In fact they got a number of photographs such as Fig. 2, showing what they call by the well-chosen name of "showers"; bursts of many tracks, all radiating from a single point which generally lies somewhere in the mass of metal surrounding the chamber. There are many interesting features of these showers; but we are here concerned with only one—the occurrence of tracks which have the peculiar aspect and appearance of electron-tracks, and some of which are curved one way and some the other. This might mean that some negative electrons are shooting out from the radiant point and some are shooting in; but it is surely one of the most deep-seated of human convictions that when tracks are seen to diverge from a common point, the objects which made them must have traveled outward and not inward, unless for one which may have provoked the flying-asunder of the rest. Or, as Anderson puts it: It is not likely that such a lot of particles would have an appointment to meet at the same place at the same time! We therefore conclude from these pictures that electrons of both the signs sprang out from these explosions.

Thus far, Pasadena and Cambridge had waited for the cosmic rays to furnish them with positive electrons; but now they began to find out how to produce these at will, and this in importance was not far behind the discovery itself. Chadwick and Blackett and Occhialini were the first to manufacture (if so crude a word may be permitted) the positive electron. Just outside the wall of the Wilson chamber they placed a piece of beryllium exposed to constant bombardment by the alpha-rays of polonium; this, as had been discovered only a little earlier, is a "source" from which both neutrons and high-frequency protons are continually being emitted; I will denote it by the symbol "Po+Be," which is becoming the usage in France. Just inside the wall they put a piece of lead. The glass was no obstacle to the great majority of the neutrons and the photons; many of them impinged on the lead, and at the expansions it was observed that cloud-tracks sprang forth from the metal, and that they had the specific appearance of electron-tracks, and that some of them were curved one way in the magnetic field and some the other.

Taking it now for proved that there are such things as positive electrons, let us examine what more is known or conjectured about them. We shall need an alternative name to interchange with "positive electron"; instead of the hybrid "positron." I will attempt to give currency to Dingle's pretty choice of "oreston" (Orestes

in Greek mythology was the brother of Electra).

A question comes up immediately: in this mixture of neutrons and photons from the "Po+Be" source which ejects the positive electrons from lead, are the neutrons or the photons responsible? Contrariwise to what was at first supposed, the photons seem to be chiefly if not altogether the authors of the orestons. Indeed, it is possible to generate positive electrons by streams of gamma-rays—high-energy photons—coming from radioactive bodies which do not emit any detectable number of neutrons at all.

Here are the data in a brief table, in which the first column contains the names of various sources of gamma-rays; the second, the energy-values (in millions of electron-volts) of the individual photons of these rays; the third, the names of various metals; the fourth, the number of positive electrons per hundred negatives, ejected from these metals by these gamma-rays; and the fifth, the authorities:

Po+Be	5	uranium	40	Joliots
		lead	30	Joliots
		lead	35	Chadwick
		copper	18	Joliots
		aluminium	5	Joliots
		lead	11	Anderson
ThC″	2.6	lead	8	Joliots
		lead	4	Chadwick
		aluminium	4	Anderson
		carbon	2	Anderson
Ra (B+C)	1.0-2.2	lead	3	Grinberg
Po	0.85	lead	0	Meitner-Philipp

The percentages in the fourth column give at the moment our best available notion about the relative plentifulness of the orestons ejected from the several metals by the several kinds of rays. One would prefer to have the total number of positives per unit intensity of the infalling rays, but that is not available at present—perhaps because of the difficulty of measuring these intensities. It must be kept in mind that the data usually consist in observations of a few hundred or even a few dozen cloud-tracks, so that the accuracy of these percentages can not be great.

We note, then, that with lead the percentage of orestons goes up rapidly with increasing photon-energy, and that with photons of five-million-electron-volt energy the percentage goes up rapidly with the nuclear mass of the bombarded atoms. Both of these rules are in harmony with a current theory of the generation of positive electrons. So are other facts of experience; but before stating them, I will state the central idea of the theory, which is simple and spectacular. A positive electron is supposed to come into being by virtue of a transmutation more drastic and amazing than any hitherto effected or imagined: *it is supposed that a photon transmutes itself into a pair of electrons, one of each sign.*

Such a transmutation—if it happens—leaves the net charge of the universe unchanged. If in addition it is to leave the net energy of the universe unaltered, we must invoke the principle of the equivalence of energy and mass: Einstein's relation,

$$E=mc^2$$

where E stands for energy and m for mass and c for the speed of light *in vacuo*. The masses of two electrons at rest, when translated into units of energy according to Einstein's relation, amount to about one million electron-volts ($1.02 \cdot 10^6$ is more nearly right, but the even million is a good round number perfectly satisfactory for these data). The residue of the energy of the photon—its original energy, minus this million—then remains over; it might go into kinetic energy of the electrons, or into a new photon, or divide itself between these forms. Here are testable consequences of the theory. If this central idea is right, then positive and negative electrons should spring forth in pairs, and the energy of each electron-pair, and *a fortiori* that of any oreston by itself, should never come within one million volts of the energy of the primary photon.

Now it is indeed a fact that positive electrons are often paired with negatives, in the sense that one of each sign appears to spring from a single point on the irradiated metal. Fig. 3 is a wonderful photograph in which a pair is seen to start from a point in the gas of the chamber. There are always some positives which are apparently unpaired; but one can resort to the excuse that the associated negative may have got caught in the metal. Millikan and Anderson are undertaking to experiment with plates so thin as to disqualify this explanation. There is also always an excess of negatives, as the table has shown; but one can always say that this excess consists of electrons expelled from the atoms by the photons in ordinary collisions. Finally, it is an empirical rule that the kinetic energy of an electron-pair or of an isolated positive never comes within a million volts of that of the primary photons. Everybody who has been producing positive electrons has been looking for exceptions to that rule, and thus far, I believe, no unimpeachable exception has been found. Another corollary of the theory is that photons of energy less than one million electron-volts ought not to produce any positives at all; and this is borne out by the negative result obtained with the gamma-rays of polonium.

In this imagined process of transmutation, charge is conserved and energy is conserved, in conformity with two familiar principles. There is yet another principle of conservation, older than either; it is Newton's third law, that the total momentum of the world ought to remain invariable. Now if we attempt to apply this principle to the pictured process, we reach a disconcerting conclusion: if a photon in the depths of space should convert itself spontaneously into two electrons, momentum and energy could not possibly both be conserved!

(Continued on page 60)

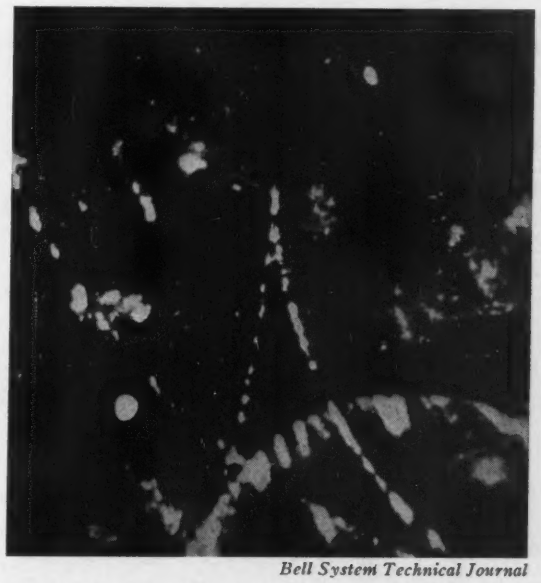


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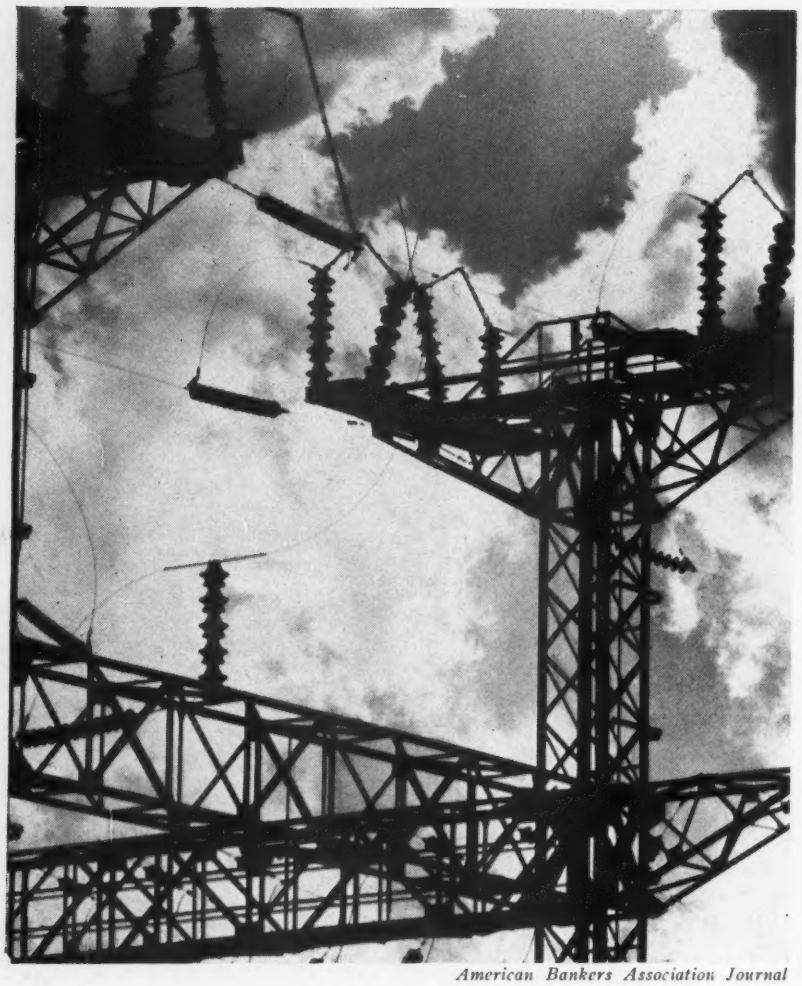
Fig. 3—Tracks of an electron pair arising in argon exposed to Gamma-rays, and probably created from a photon at its approach to an argon nucleus.



American Bankers Association Journal

HELP YOURSELF

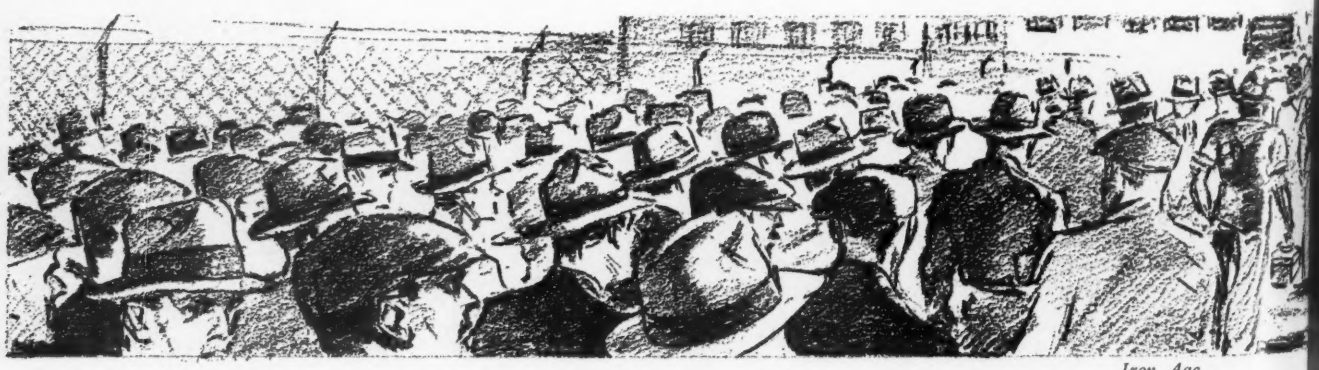
Employment for the Class of 1934

PRESENT indications are that Technology's Class of 1934 will not only get jobs but will get them in the fields of greatest desirability. This statement will not be realized one hundred per cent because there are some industrial areas where little or no contribution has been made to the average upward trend in recovery, and also because there will be a small number of students who have not done anything about getting a job and will continue to wait for something to come their way.

Last year's class, as a group, realized early in the academic year that, as Professor Schell put it, "The student market is a buyer's market and the initiative under these conditions must be taken by the seller." As a result of this realization, and in the absence of an adequate number of industries seeking technical graduates, the members of this class went into the industries and demonstrated an ability and willingness to become of immediate value. Training courses and orientation groups for new employees were, for the most part, closed down. The new man must make his own way into any concern, and upon arriving there, must immediately begin to produce.

This year the situation is somewhat easier, although industries are still employing chiefly the young men and women who show promise of immediate productivity or of exceptional long-time achievement. Test and training courses are being re-established in many of the companies, and definite plans for the recruitment of technically educated men are under way. Personnel representatives are arranging to visit the Institute to interview students; in fact, several have already made their visits. A large percentage of the students finishing at the end of the first term have placed themselves in jobs exactly in line with their abilities and desires and at good rates of pay.

Now that this encouraging side of the picture has been viewed, care must be taken that it may not engender an unwarranted optimism, or that it may not so lighten personal responsibility in the matter of placement that some of the pressing activities of the moment crowd out a well-planned procedure in getting a job. A reasonable amount of time invested judiciously during the last year at the Institute to investigate industrial opportunities has been found by experience to pay large dividends, not only in securing a good job, but in substantially contributing to the student's acquaintance with industry. It would be nearer the ideal, as a matter

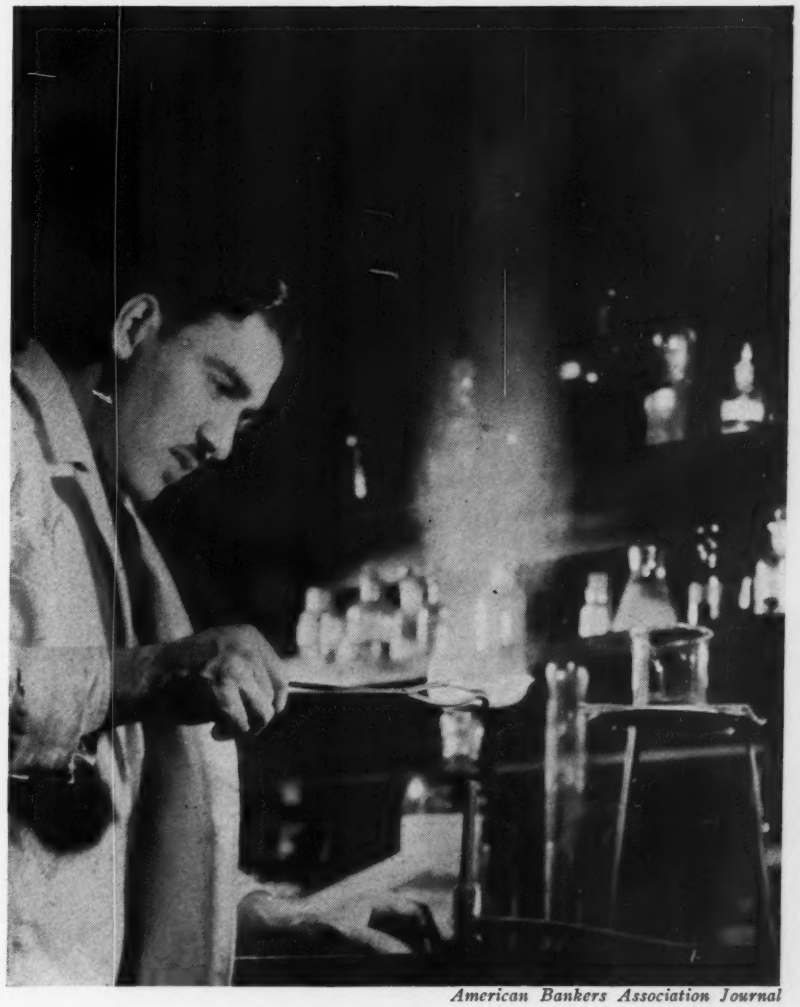


Iron Age

—TO A JOB

AN ANALYSIS OF AN INDUSTRIAL SITUATION

By KARL L. WILDES
Chairman of Placement Counseling Service for Students at M. I. T.



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of fact, if these contacts with manufacturing plants, public utilities, business concerns, consulting firms, and men of private practice, could be made by students in the early years as well as by senior and graduate students.

Opportunity plays a large part in getting a job. Back in 1929, it probably played too heavy a part. Jobs were offered to our students and in too many cases, no careful study was made to find out whether the job or jobs offered would be worth taking. Fewer misfits would have resulted in those easy years if the opportunities at hand had been set aside, though still under consideration, until some of the less obvious ones and perhaps more desirable ones were sought out. During the depression the opportunities "at hand" have not been by any means numerous and the force of circumstances has brought to the fore the necessity of investigating the job market. This necessity must be kept in the focus of attention as times become easier.

How does a student set about getting the right kind of job? There are three essential parts to the problem. First, study yourself, your abilities, limitations, and desires; secondly, study the job situation, the nature of various kinds of employment, and the requirements of each in the light of your own qualifications; and thirdly, make effective contacts with the job situations which you find consistent with your qualifications.

One of the most difficult and yet most important aspects of this undertaking is a correct self-analysis. By such a self-analysis is not meant a dreamy, wondering, contemplation of what a person would like to be, with the hope that the necessary qualities may be present, but an objective observation of personal assets and liabilities which have a direct bearing on the kind of work that can be done successfully. For example, a young engineer, himself a man of slight physical build and a highly successful engineer on delicate instruments and standardizing devices, was recently interviewing some M. I. T. men for a job which has to do with heavy machinery. He said, "I myself would not satisfy the requirements at all. The man who gets this job must be large and muscular because his work will take him into the factory where he must work with heavy machinery." On the other hand, a man with huge, clumsy hands would not be able to do the delicate experimental work with the sensitive instruments. These are physical con-

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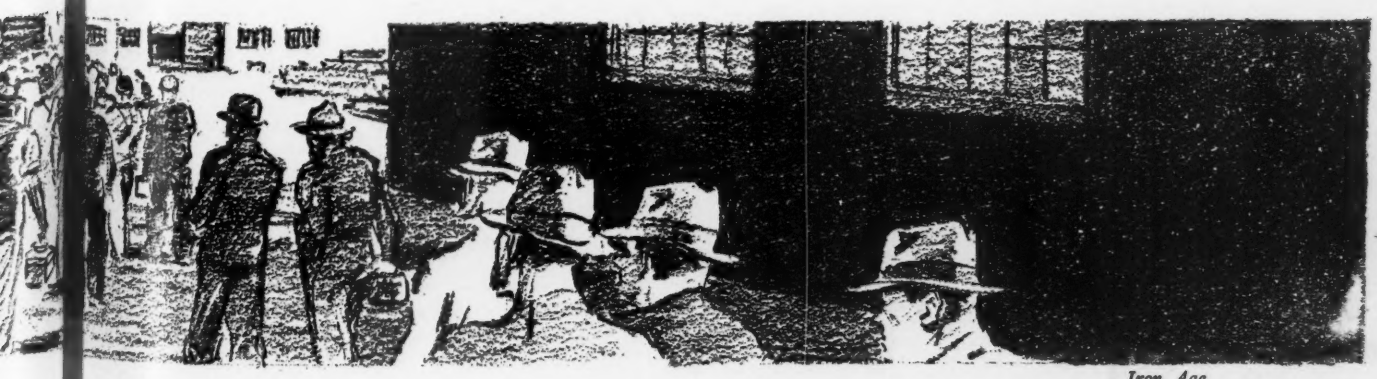

Iron Age

Designing

THE ADLER PLANETARIUM

—*An Architectural Problem*

By ERNEST A. GRUNSFELD, JR.
Architect

THE basic axiom of functionalism in Architecture, that form follows function, is true in general of all architectural design. The essence of the plan for even the simplest building is, of course, the arrangement of units best suited to the uses of the building. Here, very often, the axiom is deserted for what the architects consider "pure design,"—style. In common types of building, even when the structural problems are not simple, the engineering aspects of the building cease to become of importance to the architect as soon as the shell of the building is erected. It is then the turn of the designer to apply a style to the building.

This has been, perhaps, more especially true of what are called "special purpose" buildings, where the popular demand seems to be for spectacular ornamentation in the monumental style for public buildings. The Adler Planetarium, therefore, is particularly interesting as an example of an opportunity for a design which would be not only influenced, but directly conditioned by the specific structural aspects of the problem and by certain other considerations particular to its uniqueness.

The plan of the building is conditioned primarily by the necessities of handling crowds in circulation through the astronomical museum and by need for the efficient entrance and exit for the audience into and out of the planetarium chamber itself. The circulation problem here differs from any other type of theatrical problem. Whereas in a theater, performances occur at regular intervals, or in a cinema there is a steady infiltration and change at a relatively small scale, here there are no admittances during the demonstration in the planetarium chamber, and frequently one performance follows another at the rate of eighteen performances in a fourteen-hour day (during the World's Fair). The plan therefore includes the planetarium chamber as the kernel, with the circular corridors around it, acting as feeders to the chamber.

These corridors have been designed to house the museum exhibits, so that by directing the traffic at the entrance of the building and at any of the three exits from the planetarium chamber itself, the crowds can be handled with efficiency and safety, and have some time in the museum besides. The possibility of panics due to the required total darkness in the planetarium chamber makes necessary the inclusion of a greater number of exits from the chamber itself and more direct access to outside exits than in most buildings.

Besides the planning for the handling of crowds, the planetarium must be considered primarily as a three dimensional plan, since it is principally built as a case for the planetarium instrument. The planetarium machine is a very complicated projector which is capable of presenting the positions and movement of the stars, planets, and constellations viewed from any point on the earth's surface at any time in the past or future. It is made in two parts, one for the northern and one for the southern hemisphere, and its scope is complete so that the 9,000 stars visible to the naked eye from any part of the earth's surface can be shown, as well as the path of the planets in their orbits around the sun and the apparent changes in the sun's positions due to the rotation of the earth in its orbit around the sun. This very complicated projection machine requires a hemispherical reflecting surface or screen representing one-half the celestial globe, and therefore a large domed central chamber is needed for the demonstrations. The general form of the building, consequently, is symmetrical and cylindrical. Except for the planetarium chamber itself, which is round, the polygon was chosen as a simpler and cheaper construction. A twelve-sided design was chosen for astronomical and sentimental reasons. At each of the twelve rounded corners of the exterior, there is a fluted panel (really a form of lamination employed as a structural means of forming the granite to round the corners) with a bronze placque depicting one of the signs of the zodiac.

The framework is of reinforced concrete, built on composite piles of wood and concrete. This foundation was necessitated by the exigencies of building on made land of an exceedingly insubstantial and unreliable nature. The sixty-foot wood piles extend forty-four feet below the bed of the lake, on top of which are nineteen-foot concrete piles.

The outer dome of the planetarium consists of twenty-four structural steel ribs alternately supported by steel columns and eighteen-inch "I" beams attached to the tops of the columns. Straight horizontal struts and diagonal bracing are used as lateral support. There is a ten-foot opening at the top for smoke stack and other purposes. Cork insulation is installed under the copper dome to prevent condensation there from damaging the cloth of the ceiling in the planetarium chamber.

The basic problem of planetarium design rests in the consideration of the inner dome structure. The most difficult problem here is an acoustical one. In European planetaria concentric domes three feet apart with steel deflecting plates between them, placed at such angles that the sound waves are broken up, have been used. In the Chicago Planetarium non-concentric domes were used so as to give a greater air space in order to absorb echoes more efficiently. The lace-like construction behind the inner dome tends to break up the sound waves which pass through the material of the ceiling. For this screen, white cotton sheeting stretched tightly on wooden strips was used. This approximates very closely a perfect hemisphere, although actually the hemisphere is true only horizontally. In operation as a projection dome, it is satisfactory. In the new planetarium in Philadelphia, very thin metal sheets perforated so as to let the sound pass through have been used instead of the cloth. This material has the advantage of being capable of forming a true hemisphere, but it is more expensive and has added disadvantages in connection with lighting, which is the second consideration in the design of the inner dome and planetarium chamber.

In a planetarium chamber there must be no reflected

light from any source whatever so as to secure a maximum brilliance for the projected images of the stars. All objects in the room, therefore, must be dull and dark. Furthermore, the surface of the dome must be capable of reflecting the light rays from the projector in the truest fashion at the same time that it must let the sound waves pass through. Dust particles unevenly distributed, then, would affect the brilliance of the projected images. In the perforated metal sheets used in Philadelphia, the disadvantage, therefore, is the possible accumulation of dust particles around the perforations. In the Chicago Planetarium, the cotton dome was painted with a non-bridging lacquer after the completion of the building as an attempt to take care of this problem. The other lighting problem in the planetarium chamber concerns itself with the illusion of the horizon. On the planetarium machine, there are automatic shutters which discontinue the source of light as soon as the machine, in its revolution, would project below the horizon line. Since these shutters do not always work instantaneously, a series of baffle plates were designed to catch and disperse any stray images of stars. These are highly polished metal plates set in below the cotton dome at such angles that a ray being caught on any point below the surface will be reflected back and forth in these plates and lost to the observer. To create the illusion of reality, a metal strip painted white is hung immediately below the cotton ceiling over these baffle plates. Out of this sheet, the silhouette of the buildings of Chicago were cut. This, with the baffle plates, causes the illusion of the stars and planets rising and setting behind buildings. Actually, of course, the silhouetted buildings consist of space, black because of the arrangement of the shiny black baffle plates, and the horizon is the portion which "exists," being the white sheet metal. As a matter of fact, the illusion of reality is intensified because of the very consistency of the inversion of reality in which the sky is circumscribed and constructed, while objects are made of emptiness.

The lighting problem in the planetarium is twofold. In the first place, there is an emergency control system of lighting to carry the full load of lights since the planetarium is situated away from the main service line. This works automatically in the case of the failure of the normal source and can also be controlled by the operator at the entrance of the building.

Secondly, there is a visual problem, peculiar to the nature of a planetarium, which necessitates special lighting and which conditioned the design of the museum. Visual sensitivity tests show that it takes fifty minutes for the eye to reach its maximum efficiency in total darkness, but that in the first five minutes of this fifty minute period, eighty per cent of the adaption takes place. In the planetarium chamber itself the lecturer, by a light control, reduces the quantity of light very gradually, thereby accomplishing the threefold purpose of giving the illusion of growing darkness, of giving the audience a while in which to adjust itself to the darkness, and perhaps, more than incidentally, of explaining the planetarium machine and a few facts about astronomy.

But it seemed wise, further than this, to keep the entrance portions of the building and the museum around the planetarium chamber very dimly lighted as well, to make the visual adjustment a concern throughout the building. Therefore, except for the offices, library, and lecture room at the back of the building, there are no windows. In the corridors themselves, these walls are sombre, and the lighting fixtures are kept high above the line of vision. Astronomical transparencies line the walls of these corridors, necessitating the manufacture of a special bulb to provide the proper intensity of light and at the same time a minimum of heat. The show cases are also specially lighted. The accommodation of the eye to the later darkness is greatly increased by this dimness while the exhibits themselves are adequately lighted.

In the choice of materials and color for the planetarium, the location and use of the building were the determining factors. It is on an island, away from the rest of the city, and in a location where it is viewed from many different angles, but always as a lone building with only the lake as background. Consequently, it seemed advisable to keep it dark and sombre, as a part of the terraced land of the island. It is built of Minnesota Rainbow Granite, hung in large pieces, surmounted by a copper dome. The entrance doors are of very thick glass, faceted in such a way that when they catch the sunlight, they become brilliant and sparkling, and the small exit doors are of copper.

The only interior ornamentation is the entrance foyer. Here, there is a recessed marble dedicatory panel, with an inscription, and bas-relief symbols of the planets made of white metal. Two large lighting fixtures are suspended from the ceiling. For the exhibition halls a dark warm color was used, the lighting high up, throwing a dull light against the gold papered ceiling. The exhibits themselves are very brilliant and lighted in such a way that the source is never apparent. The intention, here, was to make the design as simple and as effective for the purposes of exhibition as possible, and to preserve the monumental quality of the building in a richness of color for both interior and exterior.

CENTRIFUGAL CASTING OF CANNON

By S. L. CONNER
1st. Lt., Ord. Dept. U. S. Army

A CANNON is a tube closed at one end used as a container to withstand, without permanent deformation, high pressures developed by burning explosives, and also to act as a guide to the projectile which is accelerated by these high pressures. Some four hundred years went by before steel tubes were used. For many years during the nineteenth century, attempts were made to produce a satisfactory cannon by casting the steel tube. But only by forging were the gunsmiths able to develop a satisfactory product. The theory of gun design* shows that transverse tensile stresses, radial compressive stresses, and longitudinal tensile stresses are set up in a cannon in action. Of these the transverse tensile stress is shown to be by far the greatest, and becomes, therefore, the limiting factor in gun construction. This fact has led to the complication of gun making by wire wrapping, shrinking, and now, cold working; in addition it makes forging a poor answer to the requirement. The forging can be made only by drawing out an ingot which causes a consequent reduction in cross section. This must inevitably give the steel a directional property, or grain, parallel to the long axis. As shown by ordinary static tests, this is manifested by the greatly improved ductility of bars taken "along the grain." The forging is better adapted to withstand longitudinal stress than transverse stress.

In 1918 Mr. W. H. Millspaugh of Sandusky, Ohio, submitted to the Ordnance Department of the U. S. Army three centrifugally cast steel cylinders. Metallurgical examination of these cylinders indicated that the process from which they were manufactured might have application in making castings for gun tubes. General C. C. Williams and General T. C. Dickson of the Ordnance Department took up the matter, and in October, 1925, the first casting for a cannon was attempted at the Watertown Arsenal in Massachusetts. A machine had been built by Mr. Millspaugh, with a mold lined with refractory. Steel for this mold was melted in a 2-ton Herrault Electric Furnace. The casting was a failure. Years of experiment followed. By June, 1930, the plant had taken the form that it has today. Within another year the process was definitely proven to be of value from the production as well as from the metallurgical standpoint.

On the extreme end of the existing plant is the switchboard control for the high frequency induction furnaces for preparing the steel. One of these furnaces is in a pit immediately in front of the board. A second furnace ($2\frac{1}{8}$ tons capacity) is mounted on a pouring car, and mounted immediately in front of this furnace is the runner box. This is a steel box lined with sand and firebrick to form a funnel with a horizontal sprue ending in a refractory-lined steel spout. When assembled in position, the spout projects about four inches into the mold, where it comes in contact with a seal which prevents loss of metal. The molds are mounted horizontally in a machine consisting of a steel cylinder about 30 inches in diameter supported by a double row of rollers on the bottom and held down by a roller under spring tension at each end. It is directly connected to a motor near one end of the machine. At the extreme end is a hydraulic cylinder which serves to apply pressure to the casting during spin, and to push the casting out after it has solidified. A second machine, similar to the first but considerably smaller, is also installed in connection with a smaller induction furnace.

Any mold may be slipped into the steel cylinder and held by passing bolts through the flanges. The finished surfaces act as bearings between the mold and the inside of the steel rotor. These molds are the most important items of the equipment. The inside is carefully bored to give the best casting from which to produce the finished gun. The outside contour is calculated to give a chill ratio of 6 to 1 at the large end, tapering down to considerably less at the small end. This contour is still the subject of considerable experimentation. The 6 to 1 chill ratio is exceptionally high and causes the steel to freeze about as rapidly as it is possible to freeze it. However, no difficulty is experienced in running the steel the full length of the molds, provided the metal is hot.

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*See, for example, "Text Book of Ordnance & Gunnery," Lt. Col. William H. Tschappat, Ord. Dept., Chapter VI.

Army Ordinance

OUR FIERY VISITORS

—*a Discussion of Meteorites*

By ***PAUL W. ALLEN '37***

AT the outset, a meteorite may be defined generally as a body from outer space which has fallen on the earth's surface. The origin of the study of meteorites was clouded with superstition and even as late as 1807, when two Yale professors described the fall of a meteorite at Weston, Connecticut, the President of the United States, expressing the general skepticism of the possibility of such an occurrence, said that it was easier to believe that Yankee professors would lie than to believe that stones would fall from heaven. But the truth of the professors' statements was later proved, however, and meteorites came to be regarded as valuable sources of information about extra-terrestrial material. The first recorded fall of a meteorite was in China in 664 B. C. Since then about four hundred meteorites have been seen to fall and a total of about eight hundred have been collected, although many of those may have fallen before 664 B. C. The Kaaba in the Sacred Mosque of Mecca is probably of meteoric origin. There are several instances of meteorites which have been preserved in European churches as objects of religious value.

Meteorites may be divided into three general groups according to their composition. The first group includes those meteorites which are composed wholly of metal and which are known as siderites. The second group, which is intermediate between the first and third, contains the meteorites which are part metal and part stone, the relative proportions of the constituents being variable. They are usually called siderolites. The meteorites of the third group are almost entirely composed of stone and are termed aerolites. It must be remembered, however, that there is no distinct line of demarcation between the three divisions and that the members of one group pass gradually into the next group.

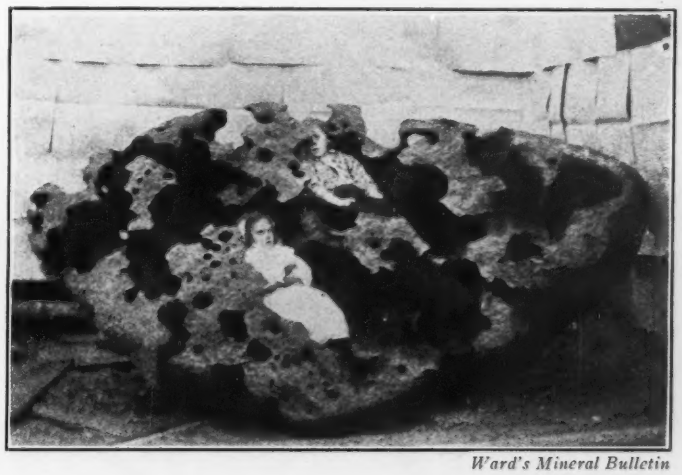
The fall of a meteorite is usually accompanied by spectacular phenomena of light and sound. In 1875 a meteorite passed over Homestead, Iowa, and the light from it was described as being almost too intense to look at with the naked eye. The meteor was round and looked as large as the sun, although the light that it gave off sparkled unsteadily. To the observers who were in the meteor's line of flight, the meteor at first seemed almost motionless and then it suddenly started off with incredible speed. During the entire flight the meteor gave off violent flashes and had a train that was estimated to be about ten miles long. The light of the train was white, but the edges were tinged a yellowish green. Near the body of the meteor itself the light was quite reddish and flashes of various other colors issued from the head. A few minutes after the meteor had disappeared, observers heard a loud crashing explosion which was followed by a hollow and rumbling sound that gradually died away.

The displays of light and sound are caused by the resistance of the air to the passage of the body. When the body first strikes the earth's atmosphere it is traveling at a very high speed. Meteors travel about the sun with planetary velocities of about 26 miles per second while the earth itself moves around the sun with a velocity of 19 miles per second. Therefore, if a meteor struck the earth head-on, its velocity relative to the earth would be 45 miles per second. If it overtook the earth, its velocity would be the difference between 26 and 19 or 7 miles per second. The atmosphere acts as a very powerful brake, but in so doing it raises the temperature of the body so high that the exterior portions of the meteor are melted in the first few seconds of flight in the atmosphere, and give off a great quantity of light. At the same time a disruptive force is created in the meteor because the rear portion still tends to travel with a planetary velocity while the front part is being slowed down. Such a force is often sufficient to burst the meteor, a phenomenon which has been observed on several occasions. The sound which usually accompanies the flight of a meteor is caused by the sudden heating and expansion of the air around the body.

So strong is the braking effect of the air that meteorites generally strike the earth with a velocity that is no greater than that which they would have had if dropped from the point at which they entered the atmosphere. At Meteor Crater, Arizona, which scientists generally agree was made by a meteorite, the body penetrated the earth to a depth of several hundred feet. The present depth of the "crater" is 570 feet, but it has of course been partly filled in by erosion of the sides. Of meteorites seen to fall, the deepest penetration was made by a 645 pound mass at Knyahinya, Czechoslovakia, in 1866, which made a hole 11 feet deep. On the other hand, a stone weighing several pounds struck ice that was only a few inches thick at Hessle, Sweden, in 1869 and rebounded without breaking either the ice or itself.

Every meteorite compresses the air in front of it as it flies through the atmosphere, but only with very large meteorites is the compression particularly noticeable. In 1908 a huge meteorite fell in Siberia. It was estimated that the main mass weighed 500,000 tons, but it has never been found. However, its effects, and the effect of the air which it compressed, were quite apparent. Over an area of several hundred square miles the trees

(Continued on page 56)



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EDITORIALS

THINKING ABOUT THINKING

LET us sit down together and think about two of the many kinds of thinking—the scientific, and the speculative kinds. All scientific thinking goes through certain steps:

First we observe the facts. This step is not easy in itself. The early pictures of a rhinoceros show him with armor and lizard scales. Most of us believe we see accurately and remember clearly, but a little experience on the witness stand soon proves how faulty is our observation, how fallacious our memory. Alan Breck said: "I've a grand memory for forgetting." And we can cry in chorus: "So have we all; but in addition we've grand memories for inventing details which we never observed at all."

Besides our psychological defects in observation, we have physical-physiological limitations as well. Our eyes can see only certain sizes, our retina is sensitive only to certain colors, our ears hear only certain tones, our fingers discriminate only certain touch sensations, and our touch-sense won't work properly unless we're neither too hot nor too cold. All of our senses act as a veil between the *real* world—forever unknowable—and the world of ideas which alone we can grasp.

To meet the ordeal of *observation* scientists have invented cameras, telescopes, microscopes, spectroscopes, the interferometer, the Geiger counter, the X-ray apparatus, the seismograph, and a thousand other devices, cunningly designed either to extend the range of our senses or to substitute for them altogether. The mere job of observing the facts is a difficult one, and requires some cubic centimeters of brain capacity.

The second step in scientific thinking is to analyze our facts, and to infer casual relation between them. This is more dangerous and difficult than observation, for we do it with our imagination; but without it we'd still be on the plane of the lower animals. Our inference is our working hypothesis, and now we're ready for the third step—we must test our hypothesis by means of new facts.

Here again we must use our dangerous imagination —we invent an experiment which will prove our hypothesis to be right or wrong. We try the experiment and again we must observe the result accurately. If the experiment sustains our hypothesis, we may venture a further inference and again check our reasoning by experimental appeal to the relentless facts. Thus, even in successful scientific thinking, we dare to move only one step at a time, constantly correcting our ideas by facts. Each success yields a bit of knowledge.

A small number of intelligent men and women carry on this work for all mankind. They get their results

only by observing accurately, thinking scrupulously, and checking what they think by cunningly devised experiments. No scientist dares to work by any other method, for no other method has ever achieved reliable knowledge.

Now in sharp antithesis to this method is the kind of thinking called speculation. There is no sequence, law or limit to speculation. All we need is our imagination. Thinking in terms of our wishes—of our opinions —of our beliefs—of our traditions—of the authority of unqualified laymen, perhaps our teachers or parents—all of these habits belong in the category of speculation. Here are some of the formulae:

"You know, these scientists don't know *everything*.

"They can give it a long Latin name, but what do they really *know* about it? Now *I* think—— . . .

"Yes, you've a lot of data, but still I prefer to believe—— . . .

"Well, we each have our opinion, and I like mine better—— . . .

"Wouldn't it be *simpler* to believe that—— . . .

"This life cannot be all," they swear. "For——how unpleasant, if it were!" (R. Brooke.)

"For nothing worthy proving can be proven, nor yet disproven." (Tennyson.)

We may begin our speculations at any point within our existing knowledge. Having seen a lady and a fish, we may speculatively construct a mermaid. We continue the picture as far as we like, endowing her with cold blood, a seductive song, and a predeliction for causing shipwrecks on Fridays, especially when there's a new moon. I grant that this particular speculation is essentially a layman's. But let's begin at a more advanced point within our field of knowledge. Knowing that the genes in the cells are organs which carry heredity patterns, a well-known biologist speculated that genes formerly lived as independent creatures until cells were invented to contain them. True, his starting point is fact which scientists obtained by the correct experimental method—but that doesn't make the speculation a bit more valid than when we invented the mermaid. It would be just as logical to suppose that the liver ran around loose until a man's body was evolved around it as a container.

And an earnest lay-reader is the more easily deceived when the speculation employs scientific terms, and especially when it's slipped into a seemingly reliable book. But Science is an inexorable mistress; those who serve her may not deviate from the one path of scrupulous study by which alone truth may be learned. And when a scientist stoops to speculation, his thoughts are not a jot more valuable than those of any other speculator. He might just as well speculate about mermaids as about genes.

The layman often calls upon us to believe that all things are possible, citing the wonders which science has disclosed as evidence for unlimited possibility; and gently reproaches the scientist as being narrow-minded for holding that some doors are shut. But a universe in which all things are possible would necessarily be a chaos; and the very fact that our universe is orderly implies that only certain possibilities exist. The scientist is neither broad-minded nor narrow-minded, he is only scrupulous.

As we close these remarks about speculative and scientific thinking, we may ask what happens when the scientist doubts. When a theory fails, are we returned to the beginning? Does the knowledge which we won by investigation under the erroneous hypothesis crumble into ignorance? It would do so inevitably if our knowledge were speculative; for each newly accepted speculation would drive out its predecessor; and each disproof would return us to the beginning, like a gambler losing a game. The exact significance of the speculative philosophy is in the Greek poet Cleon's words:

"And I have written three books or the Soul,
Proving absurd all proven hitherto,
And putting us to ignorance again."

I don't deny to you or to me the right to speculate, but let's remember that our speculations are very seductive; and probably Narcissus fell in love with his own cosmogony, not with his physiognomy. If we speculate, let's say so frankly, and never kid ourselves into believing, Narcissus-like, in our own excogitations.

FREDERICK K. MORRIS, *Professor of Geology.*

STUDENT GOVERNMENT

AN examination of the extracurricular activities shows that politics rather than ability is the criterion for awarding positions, since practically all of them are monopolized by men from one of the Institute groups which numbers about one third of the student body. It is most unnatural that the dorm men and commuters should hold but a very small percentage of the important activity positions, when their numbers are in the majority.

In fact the managing boards of some of the publications are so dominated by a minority group that it is only through the most unusual circumstances that outsiders ever get elected to managing positions; countless other examples in athletics and committees can be cited.

Perhaps the most outstanding example of politics was the freshman class elections last fall in which a publicity stunt, namely the kidnapping of the Sophomore President, proved of tremendous value. It is true, however, that such an election cannot be called illicit.

It is often questioned whether or not last year's polling on the subject of electioneering was decided purely by political strategy. Vote *NO* if you want electioneering was the requirement. Maybe it was worded in such a manner in order to perpetuate the rule of a certain group, putting the fraternities at an advantage by preventing the lawful use of electioneering among the commuters and dormitory men. It is a fact not to be denied that electioneering in one form or another exists in the fraternities. Permitting electioneering would put the dorms and commuters on an equal footing with fraternities, and it is quite possible that both the dorms and commuters might then get a fair amount of control in those offices which are decided by popular vote.

The effect of one-sided control is, obviously, very unhealthful. It lowers the competitive spirit because the reward for good work is lacking and goes to a member of the ruling group. It very often prevents the best man from getting the position. This fact is of advantage neither to the activity nor to the men involved, and it often leaves the way open for poor management.

The desire of a minority group to perpetuate control in the activities at M. I. T. has developed to such an extent that it can be definitely stated that one hundred per cent student government has resulted in failure.

Student government is successful only when personalities and politics are not the ruling factors. When a man's social affiliations, instead of his ability, becomes a strong deciding element in elections and appointments to positions on the various activities at the Institute, it is time that a new type of government be initiated.

ENGINEERING DIGEST

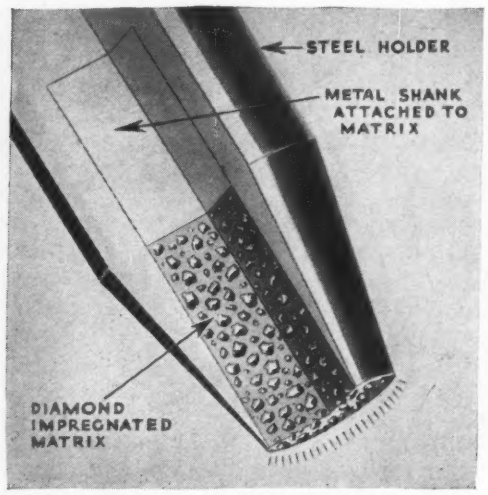
PURE CHROMIUM

UNTIL recently attempts to prepare very pure metallic chromium have been unsuccessful because of the difficulty and expense of obtaining sufficiently pure materials from which to extract the metal. Chromium produced by the reduction of chrome iron ore contains as much as 30% of iron, in addition to other impurities. Chromium was first obtained in 1797 by Vauquelin by heating carbon and chromic oxide in a graphite crucible. Of other reducing agents, such as boron, aluminum, magnesium, calcium, silicon, and hydrogen, used since that time, hydrogen was much employed because it seemed more likely to give pure chromium than the others. Unfortunately pure hydrogen is expensive to prepare, but it is essential for the successful preparation of pure chromium; only a slight trace of oxygen will prevent the reaction. Water is formed as a result of the reaction between the chromic oxide and hydrogen, and must be removed as fast as it is formed or the reaction will not proceed properly.

It is, of course, equally essential that the chromic oxide be pure. Instead of the usual ammonium chromate, chromium trioxide may be used as a starting point. The trioxide, because of its low boiling point, can be readily purified by distillation, the distillation being facilitated by carrying out the process under a reduced pressure. The distilled product can then be heated quickly to about 850° C under a very low pressure, thus forming a chromic oxide which shows only a trace of sodium and no other metallic impurities when spectrographically analyzed.

The hydrogen to be used in the reduction of the oxide, in addition to being free of gaseous impurities, must also be dry. The water content of the gas should not exceed .1% for reduction at 1100° C. The hydrides of such metals as palladium, tantalum, colombium, zirconium, and calcium offer a convenient means of producing pure, dry hydrogen.

On one experiment, calcium hydride was used. When this compound is decomposed at red heat, hydrogen is suddenly released in large volumes, forming a blast that drives away other gases. Moreover, the calcium that remains after the decomposition reacts with the moisture product of the reduction action and liberates more hydrogen. Refractory calcium oxide is also formed, but this can be leached out with dilute nitric acid. The sudden evolution of hydrogen made the vacuum pump unnecessary after the reaction had started. Further investigation showed that the reaction could be performed below red heat and, in one experiment, chromic oxide was completely reduced by calcium hydride at 470° C in 30 minutes. Analysis of the chromium showed that the metal was 99.95% pure. (*Metals and Alloys,* vol. 5, February, 1934, p. 37.)—P. W. A.



General Electric Review

Cross section view showing diamond impregnated matrix.

DIAMOND-IMPREGNATED CARBOLOY

DIAMOND is a substance which because of its excessive hardness makes the ideal substance for use in abrasive and drilling problems. The average annual expenditure in this country for diamonds used for these purposes is approximately $4,000,000. Of this amount more than 40 per cent is employed in grinding-wheel dressers, 25 per cent in earth drills, while wire-drawing dies, lath tools and stone saws consume about 25 per cent more.

Important as diamonds are in drilling and grinding, however, very little has been done to improve the technique of applying diamonds to the work so as to obtain the greatest possible efficiency from this source. From the time when diamonds were first employed in industry, they were mounted in the most obvious way that occurred to the manufacturer; and, since diamonds are peculiar in that they cannot be welded to any other body, and because their coefficient of expansion differs greatly from those of metals, it was found that the diamonds soon became loose or cracked, greatly reducing the efficiency of the drill or grinding wheel.

Consequently, for the past few years the General Electric Research Laboratory carried on an extensive investigation in order to obtain the maximum efficiency from diamonds by eliminating the breakage and loss from the holder. As a result it was discovered that under certain temperature conditions cemented carbide, such as Carboloy,[1] had a peculiar affinity for diamonds. This was very fortunate as it combined diamonds, the hardest of all substances, with Carboloy the hardest of all metallic bodies. Moreover, within a certain temperature range the coefficient of expansion of Carboloy compared quite favorably with that of diamonds and intimate contact is secured between the cemented carbon and the diamond.

Soon after this new idea was discovered, practical tests of the diamond-impregnated Carboloy were made in factories throughout the country. Two of the most important facts which these tests established were: first, a saving of about twenty-five per cent in the cost of wheel dressing through the use of this diamond-impregnated Carboloy; and second, a smoother and finer finish of the article ground. (*General Electric Review,* vol. 37, no. 2, Feb., 1934, p. 97.)—S. N.

[1]Carboloy is the registered trade mark of the Carboloy Co., Inc.

RESEARCH IN REVIEW

COURSE VIII — Physics

MUCH has been written already concerning research in the fields of spectroscopy and high voltage, but there are other branches of investigation which are of great interest to both the scientist and the engineer.

Perhaps nowhere in the country is more extensive investigation in progress on the general problem of the structure of matter than in the X-ray laboratory at the Institute, where Professor Warren is directing the work. When X-rays strike matter, they are scattered in quite definite directions because of a phenomenon known as diffraction. The nature of the pattern obtained when one allows these scattered X-rays to fall upon a photographic plate depends upon the structure of the scattering material. The laws of diffraction are known so well that it is possible, in many instances, to deduce this structure from the pictures. For a long while investigations were confined to crystalline substances. Within the past year, however, Professor Warren has succeeded in working out the necessary equations for non-crystalline substances so that it is now possible to determine the exact arrangement of the atoms in a wide variety of substances. The X-ray method is thus being applied to a study of crystals, metal alloys, sulphur in all its forms, glasses of different compositions, refractory materials, and even liquids.

Of perhaps equal interest to the engineer is the work of Professor Müller on the dielectric properties of Rochelle salts, a problem analogous with a magnetic study of iron. However, in iron it is almost impossible to obtain two samples which exhibit exactly the same behavior, whereas in Rochelle salts, since the crystals are quite large, it is possible to study the behavior of single crystals. In performing experiments there is also one more possibility with Rochelle salts than with iron; light which passes through the crystal is polarized in a way which has a known dependence upon the electric field inside of the crystal. This fact permits a direct study of the field inside of a crystal. The experiments also include the piezo-electric effect which is similar to the magneto-strictive effect, some measurements of the dielectric polarization as a function of the electric field which gives a curve analogous with the well known hysteresis loop, and many other investigations. A careful study of the hysteresis loop in Rochelle salts and in iron shows that the curve is not smooth and continuous but composed of steps. This is interpreted as meaning that the minute regions of magnetization or dielectric polarization allign themselves with the external field in jumps as the field is increased.

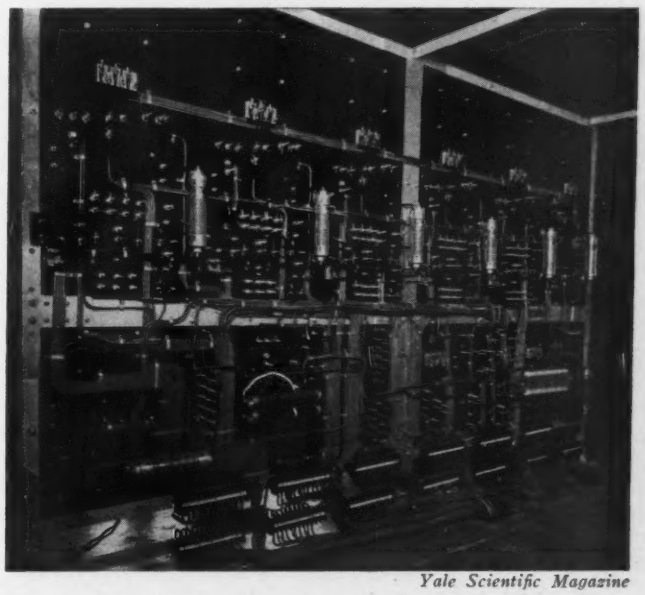
Dr. Zabel, a National Research Fellow now at the Institute, has concerned himself with the problem of what happens when two atoms or molecules of a gas collide. He allows helium gas to pass from a region of finite pressure through a series of slits into an evacuated region. After passing through the slits the gas is traveling in a beam. This beam of helium atoms is allowed to enter a chamber containing mercury vapor. The helium atoms collide with the mercury atoms and are thus scattered out of the beam. By means of a sensitive measuring device, the fraction of the beam deflected through any angle can be obtained. Now the long accepted picture of a gas has been that of countless numbers of tiny billiard balls flying about at high speeds and colliding with one another. These experiments show, however, that the atoms do not behave as though they were billiard balls at all, but as though they were tiny groups of waves.

COURSE X — Chemical Engineering

METHODS of using cheap and plentiful raw materials for the manufacture of useful products are always of interest in chemical technology. The manufacture of alcohols by the hydration of olefins derived from petroleum hydrocarbons is a case in point.

The hydration of olefins to form alcohols received attention from some of the early workers in organic chemistry and has been performed on an industrial scale by the method of absorbing the olefin in concentrated sulfuric acid, diluting the acid, and recovering the alcohol by distillation from the acid solution. Recently, attention has been centered on the possibility of conducting the reaction in such a way that combination of water and olefin occurred in the presence of a catalyst at elevated temperatures and under high pressures. Such processes are of interest because they make possible the continuous operation of the hydration process.

The hydration of olefins under high pressures is being studied from the standpoint of equilibria, catalysts and reaction rates, side reactions, and possible yields. Some of the work has been completed and some is in progress at the present time. The lower olefins have been chosen for study since they are more readily available in industrial quantities, yield alcohols which are in present industrial demand, give less difficulty from the standpoint of by-product reactions, and give rise to information which may be made use of in other processes involving the same olefins.



Yale Scientific Magazine

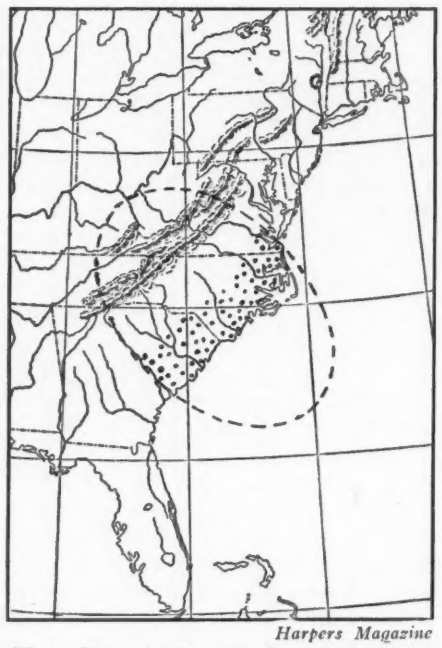
The complicated wiring panel for the automatic relays which control the operation of the new 500 KW transmitter at station WLW at Mason, Ohio.

OUR FIERY VISITORS

(Continued from page 51)

were knocked down like ten pins and many of them were scorched black by the heat of the air.

Within the last two years, the investigation of the peculiar shallow pits that are found in great numbers in the Carolinas has led to the theory that the pits were formed by a shower of huge meteorites. Some of the holes are several miles long and over a mile wide and they are very similar to the holes made by meteorites. In each hole the southeast rim is higher and at the same time the long axis of the elliptical depressions runs in a northwest-southeast direction. These two facts indicate very clearly that the meteor must have been traveling from northwest to southeast. The holes are found for 400 miles along the Atlantic coast and this distance must have been the short axis of an ellipse 650 miles long, the area which the members of the meteorite covered when they struck the ground. The conclusion is amazing, but the evidence seems to point to its correctness. The investigators were not able to fix the date of the fall, but they estimated that the visitor came between 1,000 and 50,000 years ago. Whenever it did come, the damage done by it and the compressed air must have been terrific and the forests must have been flattened out like the Siberian forest in 1908. How much more damage was done no one can tell, but the now-shallow pits were probably some hundreds of feet deeper immediately after the members of the meteor buried themselves. Subsequent erosion has filled in the pits until they have little resemblance to the scars that they formerly were, but they nevertheless afforded some idea of the magnitude of the bodies that made them.



Harpers Magazine

The ellipse indicates the approximate area of the impact of the meteorites that struck the Carolinas. Dots mark the region along the Atlantic coast where the impact scars are still visible.

Mention was made of the elliptical area covered by the Carolina meteorite. This is the usual way for a shower of meteorites to strike the ground. The heavier masses, having greater momenta, will travel further than the lighter masses and the ellipse is the result. In 1912 a shower containing 14,000 individuals fell at Holbrook, Arizona, covering an elliptical area many miles in extent. All the heavier bodies were at one end and the lighter ones at the other, while the intermediate space was occupied by the medium-sized bodies.

The terms meteor and meteorite have been used indiscriminately and it would perhaps be well to distinguish between them. A meteor may be defined most simply as a body from outer space that has entered our atmosphere and is still in flight. If that body survives the volatilizing effect of the air and reaches the ground, it is then known as a meteorite. Astronomers have estimated that 20,000,000 meteors (the "shooting stars" with which everyone is familiar) enter our atmosphere daily. As they enter the atmosphere they become heated, give off light, and almost without exception are snuffed out like a candle as they are finally consumed. The most remarkable thing about the average meteor is its small size. Their average weight is only one grain (about 1/15 of a gram or 1/400 of an ounce), yet we are able to see their light when they are from 40 to 70 miles above the earth. It is obvious, however, why practically none of them reaches the earth.

As noted before, meteorites are divided into the three general classifications of siderites, siderolites, and aerolites. With few exceptions, meteorites exhibit a pattern of intersection lines when they are etched with nitric acid. Such lines are called Widmanstatten figures in honor of their discoverer, although the first figures were produced not by etching with acid, but by heating the meteorite strongly for a long time. The pattern then appeared as different-colored lines. The figures, as they are revealed by etching, consist of bands of nickel-iron alloys of varying composition. The wider and duller bands contain approximately 7 per cent of nickel while the narrower and better-reflecting bands contain from 14 to 50 per cent of nickel. The pattern is significant in that it shows that the siderites have a crystalline structure. Each of the lines is the edge view of a plane parallel to one of the faces of an octahedral crystal.

The metal in the siderolites exhibits the same crystalline structure as that of the siderites, but in this second group the fact that the metal seems to fill in the cracks between the stony portions indicates that the metal may have been formed or introduced into the meteorite after the formation of the stone. The aerolites contain metal only as small scattered grains. The remainder is stone which, in some, bears a strong resemblance to terrestrial basalt. Certainly the stones are of igneous origin. While many terrestrial minerals, such as the silicates, feldspar and olivine, are found in meteorites, several minerals which have never been found on the earth commonly occur as constituents of meteoritic matter.

One of the characteristic features of stone meteorites is their structural arrangement. About 90 per cent of the aerolites are made up of rounded grains called chondri that vary from the size of a walnut to that of a dust grain, the majority of the chondri being about the size of sand grains. While the general shape of chondri is spherical, they may be oval, or flattened, or appear to have been deformed while in a liquid or a plastic state.

The origin of meteorites has long been a disputed matter and has not yet been definitely settled, mainly because of insufficient knowledge of the subject. Because meteorites contain silicate minerals that are also the constituents of the volcanic rocks of the earth, the theory has been advanced that they were ejected by volcanoes

and have since returned to the earth. Yet structurally the meteorites are very different from volcanic rocks, their chondritic make-up effectually differentiating them from terrestrial rocks. Even the native iron of Greenland is readily distinguished from meteoritic iron by its lack of crystalline structure.

Another difficulty in the way of the volcanic theory of the origin of meteorites is the tremendous velocity that must be imparted to a body in order to send it beyond the range of the earth's gravitational attraction. The least velocity that such a body could have would be 5 miles per second and this is far in excess of the observed velocity with which bodies are ejected from volcanoes, nor is there any geological evidence to show that such powerful volcanoes ever existed. The same arguments may be used against the theory that meteorites originated in lunar volcanoes. Even the great size of the moon's volcanoes, if they are volcanoes, is still not enough to account for the ejection of meteoritic material.

Meteor showers such as the Leonids and Andromids have been suggested as the source of meteorites, but of all the meteor showers that have been observed, during only one of these has a meteorite been known to fall. This was a siderite which fell at Mazapil, Mexico, in 1895, and since it is the only known instance of such a happening, the phenomenon was very probably a coincidence. The meteor showers, such as the Leonids which appear every 33 years in the constellation of Leo, are the remains of comets which have been broken up by the gravitational attraction of planets. Comets must have a very small mass because they are readily deflected from their orbits by the pull of other astronomical bodies, and, on the other hand, they themselves have little or no effect on the orbits of the bodies which they pass. The comets are believed to be composed of very small particles which are in loose combination. Hence the meteor showers, which are derived from comets, would have no masses large enough to penetrate the earth's atmosphere successfully.

Chamberlain has suggested that the vigorous solar eruptions that have been seen may be the source of the original material of meteorites. The eruptions are of sufficient intensity to send visibly luminous matter to a height of 200,000 miles or more above the sun's surface. Such eruptions as these may send off gaseous material that condenses to droplets of solid matter as it moves away from the sun. The droplets are prevented from uniting to form large masses by the highly agitated condition in which they are kept by the sun's heat and the sun's repellent force. It is unnecessary to go into detail about the repellent forces exerted by the sun on such particles, but it is sufficient to say that the sun tends to give the particles additional outward velocity *after they have left the sun.* As the particles move further away, the repellent force diminishes in intensity and its effect is also counteracted by the somewhat increased mass of the particles (which are still very small, however) until the backward-pulling gravitational force of the sun is felt. The particles then return toward the sun but do not re-enter it because their path has been distorted by the gravitational pull of the planets which they have passed. Therefore, the particles, or chondrulites as they are called, describe a narrow elliptical orbit about the sun. One part of this orbit is quite near the sun and when the chondrulites traverse this part they are partially melted by the sun's heat and are thus enabled to unite to form larger masses which may be the meteorites that pierce the earth's atmosphere when they fall within the sphere of that planet's gravitational attraction.

BOOK REVIEW

"VOCATIONAL GUIDANCE IN ENGINEERING LINES"—Elicited and edited by the American Association of Engineers, 1933, $2.50.

THE surprisingly large proportion of students who are dropped from engineering schools each year because of natural inability to complete the prescribed courses has so disturbed members of the engineering professions that the American Institute of Engineers decided to produce a comprehensive symposium on the subject of vocational direction for would-be engineers. The result is the 500-page volume, "Vocational Guidance in Engineering Lines," a most remarkable exposition of the opportunities and qualifications for success in almost every conceivable branch of engineering.

The book is divided into two sections: The first discusses the general aspects of the various engineering occupations and contains articles describing the more general divisions of engineering, such as the civil, electrical, and mechanical. The second and larger section deals with the more specialized branches, such as agricultural, highway, subway, and tunnel engineering.

It is doubtful that any more complete, authoritative body of information for anyone contemplating an engineering career has ever been compiled. It is definitely for the pre-college and college student; but it should even be valuable for those already established in engineering occupations. Each division of engineering is discussed in detail by successful representatives, and special emphasis is placed upon the preparation and innate qualifications required, the nature of the work, and the financial compensation to be expected.

One rather unconventional point on which most of them agreed was that the study of the English language and the acquiring of facility in speaking and writing it was one of the greatest essentials of an engineering education and that the engineer who could speak and write well was unfortunately rare. One writer advocated that English be required throughout the four-year engineering course in substitution for some of the mathematics courses.

Especially striking are the illustrations, fifty in all, which depict numerous well-known engineering constructions, such as bridges, engines, ships, canals, and skyscrapers. Although most of these represent the work of the civil engineer, because of its nature the most picturesque, most of the other major branches of engineering are also well represented. One of the most unique sections is that on Engineering Literature, in which the opportunities and qualifications for editing engineering publications are discussed.

The fact that only thirty-seven and one-half per cent of those entering engineering courses as freshmen ever graduate has given the authors and editors good reason to discourage those unfitted for engineering from taking up the profession. However, some of the contributors have perhaps carried this too far and set forth requirements which would discourage all from entering their fields except those disconcertingly close to perfection.

None the less, it is a book to be read by every student of engineering and by everyone who contemplates preparing for the profession. If the editors succeed in distributing it as widely as they plan among pre-college youths, they should certainly be able to achieve its chief purpose, a reduction of the number of those matriculants in our engineering colleges who should never have entered there.

Centrifugal Casting of Cannon

(Continued from page 50)

The largest of these molds will produce a casting having the following dimensions:

Outside diameter, breech end	11.9	inches
Outside diameter, muzzle end	8.9	inches
Diameter of cast hole	1.2	inches
Length of casting	182	inches
Weight of casting	4280	pounds

Perhaps the most interesting casting is one of the following dimensions:

Outside diameter, breech end	7.7	inches
Outside diameter, muzzle end	5.7	inches
Diameter of cast hole	0.75	inches
Length of casting	186	inches
Weight of casting	1850	pounds

Notice in the latter casting that the length is very nearly 33 times the smaller outside diameter. Over 50 of these have been made without experiencing any trouble in running the metal the full length.

From a metallurgical standpoint the equipment described above produces a remarkable product. It consists of a conical tube of steel with an axial hole extending the entire length. In a successfully poured casting the hole is exactly central and uniform in diameter. If the ladle analysis of the steel were 0.40% carbon the metal near the outside will analyze 0.35% carbon and the metal near the bore will analyze 0.55% carbon. The casting is given a normalizing and annealing treatment as follows:

Heated to 1150°C. for 27 hours, air cooled.
Heated to 950°C. for 9 hours, air cooled.
Heated to 850°C. for 9 hours, air cooled.
Heated to 650°C. for 9 hours, furnace cooled.

The micro-structure after this treatment is notably uniform and, of course, entirely free from any distortion due to working. At this point the casting is rough turned and rough bored, after which it is heat treated as follows:

Heated to 875°C. for 9 hours, water quenched.
Heated to 690°C. for 7 hours, furnace cooled.

After this treatment a fine uniform structure is produced throughout a mass of steel weighing as much as two tons. The composition of the steel used is:

Carbon	*Manganese*	*Silicon*	*Sulfur and Phosphorous*	*Molybdenum*	*Vanadium*
.35-.45	.60-.80	.15-.25	.02	.25-.35	.10

and the last seventy-five cast cannon have had physical properties lying within the following limits:

Limit of proportionality	68,000- 78,000	pounds/inch²
Tensile strength	92,000-102,000	pounds/inch²
Elongation (in 2 inches)	24-30	per cent
Reduction	60-70	per cent
Tensile charpy	32-45	foot pounds

These properties obtain transversely, and also longitudinally or diagonally, and they are produced without hot or cold work of any kind.

This composition of steel was developed at the Watertown Arsenal for the purpose. The properties proved so desirable that samples of the steel were prepared and tested commercially by a prominent American corporation. After normalizing at 925°C., water quenching from 850°C., and drawing back to 700°C., the following results were obtained:

	Limit of proportionality	*Yield point*	*Per cent elongation*	*Per cent reduction*
Sand cast test lug	86,500	110,000	20.3	50.8
Forged 1 inch square	98,500	112,750	23.0	68.8
Forged 2 inch square	79,500	100,250	26.5	70.7
Forged 4 inch square	71,500	94,750	25.3	67.7

These results are the average of two bars in each case. Test specimens were all longitudinal taken from the center of the cast test lug and the 1 inch square, and from the mid-wall of the 2 inch and 4 inch squares.

Transverse bars taken from the mid-wall of the 4 inch square (forged from 7 inch octagonal ingot) gave the following results, average of two bars, after the same heat treatment:

Yield point	*Tensile strength*	*Per cent elongation*	*Per cent reduction*
79,000	100,350	20.0	44.9

This metal was especially prepared for testing, and gives results probably somewhat superior to those commercially obtainable. It is evident that the results given by the centrifugal castings are good. Considering the castings further, the following metallurgical points are interesting. Although there is a segregation of carbon across the entire wall of the tube, the metal is remarkably homogeneous. The carbon segregation is, of course, desirable for the purpose. Careful determinations of density give, consistently, slightly higher values for the centrifugally cast steel than for the same composition forged. This is explained by better elimination of gas and other non-metallic matter during freezing.

There can be no question that the process is of great interest and value as a method of manufacturing cannon. It is a logical development in the effort of man to produce superior weapons; an effort which has led the way in the production of high grade metal for generations.

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Employment for the Class of 1934

(Continued from page 47)

siderations, but there are others of importance. It would be folly to select an impulsive, careless, although brilliant and ingenious type for work in a high-voltage laboratory where a constant and studied attention must be maintained to prevent loss of life and property.

To suggest a systematic way to go about the process of personal analysis, a set of objective facts may first be written down. The items may be somewhat as follows:

1. My record up to date.
2. Qualities responsible for the record.
3. General fields of endeavor for which my qualifications fit me.

The record should include: education, jobs held, and spare-time activities or hobbies. The expansion of the first of these topics will show which were the subjects studied with ease and which with difficulty, which were interesting and which boring. Did you get satisfaction in carrying through an assigned problem or are you prolific in ideas but not desirous to pursue any of them deeply? Which teachers did you like best and what were their characteristics? Have you been sought by other students for conferences on your mutual studies because of your clear understanding of them, and which subjects were these? What were your extra-curricular activities?

What were your attitudes toward the jobs held during school vacation or other periods? Did you show a flare for the financial aspects or did you take more interest in the doing of the job technically? What evidence do you have that your work was satisfactory or highly commendatory to your boss? How did you get along with your workmates? Have you been picked as "chief" anything in any of these jobs?

Are your hobbies indoor or outdoor? Do you indulge in them alone or do they involve the association with others? Do they require chiefly mental concentration or do they involve chiefly physical development? Do they require you to be energetic or do they incline toward inactivity?

These questions and suggestions do not represent the totality of important ones to be answered in the record but are illustrative of considerations which form an experimental basis for judgment of abilities.

The second item in the self-analysis goes more deeply and attempts to show why the elements of the record are as they are. What are the fundamental attributes which have caused you to make your achievements? Have you just drifted through these experiences merely because of opportunity, or have you exhibited clear planning and strong determination to carry your plans into effect? Are you industrious? How is your judgment? Are you practical? Is your character sound; that is, can you depend upon yourself and can others depend upon you to do a job? Do you like people generally or do you have many strong personal dislikes? Are you extremely argumentative? Have you learned to reason calmly and accurately, or are you emotional and sentimental in reaching conclusions? Again these are only sample questions out of many pertinent ones.

The general fields of endeavor consistent with the qualities just considered may now be determined. This involves a survey of the fields of science and engineering to see where a person's talents can be applied with the greatest satisfaction. One way to begin the study is by means of a functional analysis of industry, as suggested by the topics: research, development, manufacturing, engineering sales, patent law, etc. Functional areas outside the student's aptitudes and desires can be left for secondary consideration, but the others should be studied more minutely. For a general description of employment in science, engineering, and architecture, the reader is referred to a book entitled, "Jobs for the College Graduate in Science," by E. J. v. K. Menge. Each of the engineering professions is described in a new book sponsored by the American Association of Engineers entitled "Vocational Guidance in Engineering Lines."

Finally, how does the student establish contacts with a prospective employer after a desired field or specific companies have been decided upon? The following definite suggestions may be made:

1. Talk with your professors and any personal acquaintances in industry.
2. Use the industrial directories.
3. Keep watch for visits at the Institute of representatives of industrial concerns in your line of interest.
4. Watch for news items in magazines and newspapers concerning the rise of new and unusual industries.

In order to get the facts concerning placement before the students and to stimulate them to activity in this important matter, the Institute has established a Placement Counseling Service for seniors and graduate students. This service is organized under the sponsorship of the Administrative Officers of the Institute and provides at least one Faculty Counselor for each of the eighteen courses and additional counselors in the larger courses. These men have been chosen because of special aptitudes for this work, such as intimate contact with industry and knowledge of personnel requirements in various kinds of work. Their primary function, as far as placement is concerned, is to make themselves available to undergraduate and graduate students for advice and guidance, not only in the matter of immediate job-getting but in making a sound general analysis of their employment problems. The salient objective in the minds of this staff of advisers this season is to aid every student to get the *right* job.

Some features of this problem need to be placed before all the students, and these are being presented in a series of nine lectures open to the whole senior and graduate classes. The more efficient presentation of these features in this fashion relieves the course advisers from the task of doing it individually, thus conserving the time of these men for dealing with the more specific and individual matters.

The actual getting of a job in a specific field evidently bears some relation to the number of contacts made and the earnestness and conviction with which the student goes after these jobs. Any weak or superficial attempt to get a job and any lack of determination to be of continued and increasing service after the job is obtained deserves to be rewarded with failure. On the other hand, industry needs men who can not only solve the problems handed out to them but who can find out what problems ought to be solved. The latter type of man can get a good job this year.

The Positive Electron

(Continued from page 45)

This seems at first to impair the theory greatly as it is not without the greatest reluctance that physicists would forego the conservation of momentum. We recall, however, that orestons have not been shown to spring into existence in the depths of space, but only where a beam of photons is traversing a sheet of matter, or at any rate a gas. This suggests that the nucleus of some atom enters into the process, to the extent of receiving enough momentum to balance the budget; and inversely that the process can not occur unless there is a near-by atom available to serve this purpose. In the fully-developed theory, indeed, an atom is always introduced to play this role. The electron-pair of which the tracks are depicted in Fig. 2 sprang into existence in a chamber full of argon, and we suppose that it was born near an argon nucleus.

This is a theory of the first importance. Here we witness, it may be, the disappearance of the last apparent barrier in physics: the barrier which seemed to separate the substance of electricity and matter from the substance of light. We have long been accustomed to the idea, and perhaps we shall soon be accustomed to the fact, of every sort of transmutation among the divers elements of matter; but the idea of transmutation between matter and light is one which will require years to realize in all its implications. Perhaps, however, it would be well to be a little cautious, awaiting the results of further tests which the quantum-mechanical theory invites; not yet is it safe to discard the idea that these electrons, of whichever sign, may simply have been expelled by the photons from atom-nuclei where they have previously been existing. I therefore bring this story to its end not with a pæan of triumph to the theory, but with a description of the latest and most potent method of producing orestons, discovered by the Joliots hardly more than half a year ago.

What the Joliots observed was the emission of orestons from a leaf of aluminium foil exposed to the bombardment of alpha-particles from polonium. Later on they observed the like effect when targets of boron or beryllium were substituted for the aluminium. (It is easy to confuse this observation with the earlier one, in which the rays emitted by the bombarded beryllium were found to evoke positive electrons from a second piece of metal: but in this later work the positives which were observed came forth from the beryllium itself.) It may well be an accompaniment of transmutation, for the alpha-particles which cause it likewise possess the power of transmuting all three metals. It is not a universal effect, for it is not observed when lithium is substituted for the aluminium (this proving incidentally that the positive electrons are not from the polonium itself). From aluminium the number of orestons emitted is of the order of one to every couple of million of incident alpha-corpuscles; and several months ago Joliot composed a source capable of producing thirty thousand positive electrons to the second. By comparison with the mighty torrents of negative electrons which flow in any technical vacuum tube, these feeble currents may seem trivial. That, however, is not the proper standard of comparison. One should rather say that in the autumn of 1932 positive electrons were being observed at the rate of three or four a year, and already in the summer of 1933 this rate had been enhanced to thirty thousand in the second.

In January of this very year of 1934 (and the third month of this year is not yet at its close as I write these words!) M. and Mme. Joliot made a further discovery—perhaps to be regarded in future generations as the greatest to which the initial discovery of the positive electron was destined to lead. They observed that when aluminium (or boron or magnesium) is exposed for a time to the impacts of alpha-particles, the emission of orestons does not cease as soon as the bombardment is suspended, but goes on for an appreciable time! There must be *two* "reactions"—to borrow the chemical term—initiated by the impacts; after the reaction (whatever it may be) which occurs when the alpha-particle impinges on the nucleus, there must occur another of which the positive electron is the offspring, and there must be a lapse of time between the former and the latter. The outflow of orestons diminishes according to the exponential law after the moment when the impinging beam is intercepted, and this signifies that the lapse of time aforesaid is not fixed, but varies from one atom to another in the manner which we call "statistical." This is the very law according to which the activity of radium and other radioactive bodies dies away, and consequently this delayed emission of orestons is called "induced radioactivity." From ordinary radioactivity it differs in that no element exhibits it before bombardment with alpha-particles; also, no radioactive element has hitherto been observed to emit orestons.

Inasmuch as boron is known to emit neutrons when bombarded by alpha-particles, the Joliots suspected that the first of the reactions is that described by the equation,

$$_5B^{10} + {}_2He^4 = {}_7N^{13} + {}_0n^1$$

where the symbols in their order signify: a boron nucleus of mass 10 (ten-sixteenth of the mass of an ordinary oxygen atom) and charge 5 (five times the electron-charge); a helium nucleus (alpha-particles) of mass 4 and charge 2; a nitrogen nucleus of mass 13 and charge 7; a neutron of mass 1 and charge 0. It must be conceded that no nitrogen nucleus of mass 13 has yet been observed; but, after all, this is no objection but an advantage! We are looking for an unstable nucleus, and here we have one that is so unstable that, if it ever existed on earth, it has not survived. For the second of the reactions, the Joliots suspected

$$_7N^{13} = {}_6C^{13} + {}_1e$$

where $_6C^{13}$ signifies a carbon nucleus of mass 13 (this is a rare kind, but it is known) and $_1e$ is a positive electron. At first this was only a clever guess. Presently, however, they bombarded boron nitride with alpha-particles, until a good stream of orestons was pouring forth; then they removed the source of alpha-particles, and to the boron nitride they applied a reagent which was capable of removing all the nitrogen and sending it away in a stream of ammonia; the emission of positive electrons continued from the ammonia, but ceased altogether from the boron which was left behind! In the last month, observers of at least three other laboratories in widely-separated places have published word that they have observed additional cases of induced radioactivity; and however rapidly the editor of this journal may get this article into print, it is altogether probable that some new revelation will anticipate it in the daily press.

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INDUSTRIAL BIOLOGY
MATHEMATICS
MECHANICAL ENGINEERING
METALLURGY
MILITARY ENGINEERING
MINING ENGINEERING
NAVAL ARCHITECTURE AND MARINE ENGINEERING
PHYSICS
SANITARY ENGINEERING

The Course in Architecture is of five years' duration, and leads to the degree of Bachelor in Architecture. Five-Year Co-operative Courses in Electrical Engineering and Railroad Operation leading to the degrees of Bachelor of Science and Master of Science are also offered.

Graduate Courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy, Doctor of Science and Doctor of Public Health are offered. The Courses leading to the degree of Master of Science include Co-operative Courses in Chemical Engineering Practice and Fuel and Gas Engineering.

The better high schools and other preparatory schools in the United States offer adequate preparation for the required entrance examinations given by the College Entrance Examination Board in June, or by the Institute in September.

Graduates of colleges or of scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding approximately to at least one year's work at the Institute, are admitted to such advanced standing as is warranted by their previous training, and are given credit for our required subjects, including the entrance requirements, so far as they have been satisfactorily completed.

The Summer Session extending from June to September includes most of the subjects given during the academic year and in addition special courses for teachers.

Any of the following publications will be sent free upon request

CATALOGUE FOR THE ACADEMIC YEAR
(WHICH INCLUDES THE ADMISSION REQUIREMENTS)

SUMMER SESSION CATALOGUE

GRADUATE STUDY AND RESEARCH

Correspondence should be addressed to the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

G-E *Campus News*

A NEW MOVIE STAR

Lightning, commonly considered a "bad actor," plays the leading role in a sound-motion picture just released. Contrary to expectations, he gives a good performance; in fact, some critics say he "electrifies" the audiences. The picture, "A Modern Zeus," was made to illustrate how the terrific force of lightning has been reproduced in the General Electric high-voltage laboratory in order that its effects may be studied and means devised to safeguard life and property against its attacks.

The film traces the common fear of vast electric discharges, from its earliest manifestations in mythology, down through the "lightning-rod era," and pictures the ravages wrought by freakish bolts. The studio, or laboratory, scenes show the discoveries of Edison and of Steinmetz, and the laboratory at the General Electric Works at Pittsfield, Massachusetts, where artificial lightning discharges of up to 10,000,000 volts have been made. The charges leap across space, shattering blocks of wood and model buildings, and fusing sand into glass. The effects of lightning's striking models of the Chrysler and Empire State buildings in New York add to the spectacular nature of the picture. The laboratory where the actor was trained is directed by K. B. McEachron, Ohio Northern U., '13, M. S., Purdue, '20, and the picture was made by General Electric's cinematographer, John Gilmour, Union College, '27.

FREER WHEELING

For a stretch of 30 intersections along Michigan Avenue, Chicago, traffic speed has averaged only 13 mph. Chicago traffic engineers made a thorough 5-year study of the situation and designed a system of traffic control, based on the recommendations of several other nationally-known traffic experts, that is the most modern in the world. Here are some of its features: It is a progressive system that will practically double the present average speed of travel. Northbound traffic at certain intersections will be managed independently of southbound traffic. Flashing green signals will tell a driver whether he is going too fast or too slow to make a nonstop passage. A special controller will cut in to operate the lights at the Chicago River immediately after the bridge has closed, to allow waiting vehicles to clear. Even the previously neglected pedestrian will have a blue-white signal to guide him.

When the three Chicago municipal government bodies involved decided, last year, to install the system, it was found that General Electric traffic-control apparatus would meet all the unusual and complicated conditions. General Electric obtained the order, and the system is now being installed.

Ralph Reid, M.I.T., '24, was responsible for the design of the equipment, and C. H. Rex, Illinois, '26, G-E traffic-control specialist in Chicago, aided in the preparation of final plans.

ANTARCTIC AIR MAIL

In Schenectady, N. Y., there is a mailman who has, without a doubt, the longest route in the world. Every two weeks he delivers letters and postcards to eager recipients about 10,000 miles away—yet every one arrives on time. These letters go by air mail in the truest sense of the word, because they are broadcast by the General Electric short-wave station, W2XAF. Their destination is the camp of the Byrd Antarctic Expedition in Little America. Mailman K. G. Patrick, U. of Michigan, '29, of the Company's Publicity Department, occasionally gets some unusual requests. Once, a youthful balloonist wanted to send an aërial picture of himself to Admiral Byrd, but the mailman had to compromise by describing it. Letters come from all over the world, and about half of them wind up with a request for a penguin.

This air mail goes through regularly and quite clearly, thanks to a special directive antenna designed by Dr. E. F. W. Alexanderson, Kungliga Tekniska Hogskolan, Stockholm, Sweden, 1900, a G-E consulting engineer. For the benefit of short-wave radio enthusiasts: this antenna is of the horizontal checkerboard type, especially adapted to sending horizontally polarized radiations. The effectiveness and carrying power of these radiations were discovered by Dr. Alexanderson in 1924. Incidentally, W2XAF operates on a wave-length of 31.48 meters, or 9,530 kilocycles, and these programs are broadcast every other Sunday night, starting at 11 o'clock, E.S.T.

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GENERAL ELECTRIC